3 Nature and Extent of Contamination

In this section, we describe the type of contaminants at the site (nature) and the distribution of these contaminants across the site (extent). The nature and extent of contamination was determined based on data collected for the RI.

Petroleum hydrocarbons are the most widespread and significant group of contaminants in the site. They are present throughout much of the site in soil, groundwater, and sediment. These have been tested for as TPH in the diesel and motor oil range throughout the site. In addition, the hydrocarbon composition and hydrocarbon constituent compounds have been tested from selected samples as polynuclear aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene and xylenes (BTEX); and extractable and volatile hydrocarbon fractions (EPH/VPH).

Plumes of free product extend from the railyard northwest to the Skykomish River (Figure 3-1). The free product plumes act as sources for soil contamination and for dissolved hydrocarbons in groundwater. The highest concentrations of TPH within all impacted media typically coincide with the locations of free product. The extent of free product has been more extensive in the past than at present; the areas that typically formerly contained free product, now contain high concentrations of residual TPH and the soil is heavily stained with hydrocarbons. These areas still contain high concentrations of TPH in the soil and groundwater.

Metals, specifically lead and arsenic, are also contaminants within the site. The metals impacts are generally restricted to shallow soil on the railyard, although there are some isolated elevated concentrations of lead in shallow soil in the residential and commercial area north of the railyard

Polychlorinated biphenyls (PCBs) have also been detected in soil at the site in a limited area. These are related to a former substation and transformers on the railyard. They are restricted to the shallow soil on the railyard.

The contamination across the site is present within similar lithologies; however, the methods that may be used to clean it up vary in different parts of the site because of surface constraints and differing cleanup requirements. Figures 6-2 through 6-6 in the Supplemental RI (RETEC, 2002) show the affected lithologies. These cross sections indicate that contamination is predominant within sand and gravel and does not extend far into the underlying silt. Site cleanup zones (Figure 3-2) have been developed for the site to facilitate development and description of remedial alternatives, and designate areas of the site that may be amenable to common treatment technologies. The site has been divided into zones based on land use (railyard, commercial, residential), land type (wetland, levee, upland) and

TPH composition. Based on the above assessment, the following zones were created:

- **Aquatic Resource Zones** – Includes the Skykomish River, the levee and the former Maloney Creek channel

- **Northeast Developed Zone** – Includes land that has been or will likely be developed for commercial or residential use and is affected by petroleum plume primarily composed of diesel fuel

- **Northwest and South Developed Zones** –This includes land that has been or will be developed for commercial or residential use. The smear zone soil and groundwater have been impacted by plumes consisting of a mixture of diesel and bunker C, and isolated elevated concentrations of lead in surface soil.

- **Railyard** Zone – Includes land historically used for industrial purposes and portions of two immediately adjacent residential properties. The soil in this zone has been impacted by petroleum hydrocarbons (diesel and bunker C) in the surface, vadose and smear zone, and by lead and arsenic in the surface soil. Some groundwater within the zone contains dissolved petroleum hydrocarbons and there are some small areas with free product. This land is all owned by BNSF, except for the two residential properties that are owned by James W. Hawkins and Lorna M. Goebel.

The zones are described in more detail in Section 6 and are referred to in the remainder of this section.

3.1 Soil Quality

Soil samples have been collected from locations throughout the site and have been analyzed for petroleum hydrocarbons (TPH-Dx, EPH/VPH, PAHs, and BTEX), lead, arsenic, PCBs and dioxins. The soil samples have been collected to support several site investigations; the most extensive of these was reported in the RI (RETEC, 1996) and in the Supplemental RI (RETEC, 2002a). Details of the other investigations are provided in Section 2 of the Supplemental RI Report (RETEC, 2002a). The soil samples have been collected from several depth intervals ranging from the ground surface to approximately 20 feet below the ground surface. These depth intervals have been defined as the surface, vadose, smear and saturated zones, and are described below.

- **Surface Zone.** The surface zone has been defined as the upper 6 inches outside the railyard and the upper 2 feet in the railyard.

This is the uppermost soil within the vadose zone, however this uppermost interval has been designated as the surface zone to distinguish those impacts that do not extend far below the ground surface. The soil in this zone is unsaturated with groundwater at all times.

- **Vadose Zone.** The vadose zone is located between the surface zone and the smear zone. This zone is located above the water table under normal conditions and consists of unsaturated soil. Contaminants within this zone will migrate vertically downwards under the influence of gravity and will not be transported by groundwater flow. This zone varies in depth and thickness throughout the area. The top of the vadose zone always underlies the base of the surface zone. The base of the vadose zone corresponds to the maximum groundwater levels and the top of the smear zone. This depth averages approximately 4 feet north of the railyard and is approximately 10 feet in the vicinity of the railyard; as a result, the thickness of the vadose zone varies between 2 and 8 feet. In a few low-lying areas and close to the barrier wall, the base of the vadose zone may be as shallow as 2 feet below the ground surface or may even be absent because of high water levels that may intersect the ground surface.

- **Smear Zone.** The smear zone is defined as the range of depths within which the groundwater will fluctuate under normal seasonal conditions, and therefore, in which free product would move and "smear" the soil in response to these seasonal changes in the water level elevation. The smear zone soils may therefore be saturated or unsaturated with groundwater at any given time. In addition to groundwater fluctuations influencing contaminant migration, the contaminants may be transported laterally through the aquifer in the direction of groundwater flow by the movement of groundwater.

  The top of the smear zone varies from a minimum depth of 2 feet near the barrier wall to a maximum depth of approximately 10 feet in the railyard. The base of the smear zone ranges from an approximate depth of 10 feet near the barrier wall and north of the railyard to a maximum depth of approximately 18 feet on the railyard. The thickness of the smear zone varies according to the groundwater elevation and the depth to groundwater; typically, it is 5 to 10 feet thick. In areas where the ground surface is much lower than the surrounding area, the smear zone is closer to the ground surface. The former Maloney Creek channel is an example of this. In the former channel, the depth to groundwater is typically very shallow and may actually be at the ground surface when the groundwater levels are high. Therefore, in the Maloney Creek area, the smear zone may extend to the ground surface

- **Saturated Zone.** The saturated zone is defined as the depths where groundwater is always present regardless of groundwater elevation fluctuations. The top of the saturated zone is the base of the smear zone. Since free product floats on and near the water table, it does not enter the saturated zone. The base of the smear zone is the top of the saturated zone and occurs generally between 10 and 18 feet below the ground surface.

3.1.1 Petroleum Hydrocarbons in Soil

Petroleum hydrocarbons are present within the surface zone, vadose zone and smear zone in parts of the site. Soil samples have been analyzed for TPH (as diesel and motor oil) using methods WTPH-D, NWTPH-Dx, NWTPH-D and EPA Method 418.1. In addition, fractionation data on specific carbon chain-length hydrocarbons were collected from samples at depth using EPH/VPH and selected soil samples have been analyzed for BTEX and PAHs.

3.1.1.1 Total Petroleum Hydrocarbons in Soil

The analyses show that TPH is present in the surface, vadose and smear zones within the railyard. The concentrations of TPH (diesel and oil) in vadose and smear zone soil are presented in Figures 7-2 though 7-6 of the Supplemental RI. In general, the surface and vadose zone impacts coincide with historical railroad operational areas that acted as sources of contamination, although some surface zone impacts were also caused by road asphalt. These operational areas included the fueling station and diesel tank, and areas topographically downgradient from the oil unloader pits, timber oil sump and soil pump house.

TPH is more widespread in the smear zone. Figures 3-3 and 3-4, which show the extent of contamination in the vadose zone and smear zone, respectively, have been revised since the data were presented in the Supplemental RI (RETEC, 2002a) to ensure that the extent of contamination in the soil is consistent with the extent of TPH in groundwater and location of free product. In addition, Figure 3-4 has been revised to provide a conservative estimate of contamination for designing the remediation systems for the site.

In the smear zone, TPH is generally located in areas coincident with the vadose zone impacts and is hydraulically downgradient from those impacted areas. This reflects free product migration with groundwater downgradient (to the northwest) from the former operational areas. The maximum TPH concentrations are 13,400 mg/kg, 30,700 mg/kg and 40,000 mg/kg in the surface zone, vadose zone and smear zone, respectively (RETEC, 2002a –

Table 7-2). No free product was present in the surface or vadose zone during the field sampling. The residual saturation in the vadose zone varies with differences in the lithology throughout the site. These data indicate that the residual saturation on the railyard may be as high as 30,700 mg/kg.

The saturated zone samples indicate that contamination has not been detected in soil more than 25 feet below ground surface. In addition, groundwater samples collected from wells (DW-1 through DW-5) completed below the silt have not contained detectable concentrations of hydrocarbons (RETEC, 1996). This indicates that the silt bed that underlies the site at approximately 15 to 25 feet is an effective barrier to vertical migration of contaminants.

3.1.1.2 Composition of Hydrocarbons in Soil

Diesel fuel and bunker C were historically used on the railyard. As such, the petroleum hydrocarbons present throughout the site consist of these two fuels in varying proportions. Soil was analyzed for diesel and bunker C using the NWTPH-Dx method. The NWTPH-Dx method reports TPH as diesel (C9 to C24) and oil (C20 to C32). Diesel fuel generally includes hydrocarbon ranges C9 to C20 whereas bunker C is a fuel mixture that generally contains both diesel range and oil range hydrocarbons (C9 to C32). Therefore, TPH-diesel analysis will provide the concentration of diesel fuel and/or the lighter hydrocarbons in bunker C within a sample, whereas TPH-oil will only provide concentrations of the heavier hydrocarbons present in bunker C. As a result the relative extents can be determined from the concentrations of TPH-diesel and TPH-oil; TPH-oil is used to assess the extent of bunker C only. Furthermore the ratio of TPH-diesel to TPH-oil indicates the relative proportions of diesel to bunker C within the samples. The diesel: oil ratio varies considerably throughout the site, indicating that the composition is not uniform; this is consistent with visual observations made during collection of the soil samples. These observations showed the product to be an emulsion (or immiscible combination) of bunker C and diesel. The geometric mean of the diesel: oil ratio for all soil samples is 1:1.3; however this ratio varies from a maximum of 10:1 to a minimum of 1:10. The ratio of diesel to oil also varies depending upon the depth from which the soil sample was collected. The geometric mean of ratios from the surface and vadose zones is 0.5, whereas the geometric mean of samples from the smear zone equals one. This indicates that there is relatively more diesel in samples below the high groundwater table than in the vadose zone. Diesel constitutes the lighter weight, more mobile hydrocarbons, and therefore this observation is not surprising.

3.1.1.3 Extractable and Volatile Petroleum Hydrocarbons in Soil

EPH/VPH samples have been collected from soil samples in the vadose, smear and saturated zones both inside and outside the railyard (RETEC, 2002a). These analyses indicate that the petroleum hydrocarbons consist mainly of C12 to C34 carbon ranges for aromatics and aliphatics; this is consistent with the diesel and motor oil range hydrocarbons present at the site, and indicates that both diesel and bunker C are present in these samples. Further details of the hydrocarbon ranges detected in the soil samples are provided in Section 7.1 of the Supplemental RI (RETEC, 2002).

3.1.1.4 Polynuclear Aromatic Hydrocarbons in Soil

PAHs have been reported in soil samples from the site; these are generally reported in the soil samples that contain the highest concentrations of TPH. These samples are in former source areas or in areas within the smear zone with free product or high concentrations of residual petroleum hydrocarbons. All PAHs that have been tested for have been detected in soil samples; the most widespread include acenaphthene, fluoranthene, fluorene and pyrene. Further details, including a more complete discussion of the results, are presented in Section 7.5 of the Supplemental RI.

Benzene, Toluene, Ethylbenzene, and Xylenes in Soil

BTEX compounds are not common constituents of the petroleum hydrocarbons, though low concentrations have been detected. The low BTEX concentrations are not surprising considering that the petroleum hydrocarbons used at the railyard are primarily composed of the heavier-end hydrocarbons, and that the releases occurred at least 30 years ago.

3.1.2 Metals in Soil

During initial investigations, arsenic and lead were identified as the primary metals of concern and are, therefore, the only metals that were subsequently investigated. Samples were collected primarily from surface zone soils; however, several samples were also collected from shallow subsurface soils.

3.1.2.1 Arsenic in Soil

Arsenic (Figure 3-5) is present at concentrations above MTCA Method A concentrations (20 mg/kg) on the railyard. The majority of samples with levels above 20 mg/kg were collected near current and former railyard facilities. The sources of arsenic in soil are not completely understood; arsenic is commonly associated with treated railroad ties and therefore the distribution may be associated with areas in which the ties were stockpiled. Arsenic is also frequently present in sandblasting grit, and therefore the arsenic may be associated with some historic sandblasting operations. Elevated arsenic concentrations have also only generally been detected within samples from the upper 2 feet of soil collected from the railyard. Only one deeper sample (MW-31 at 4 feet bgs) contained arsenic greater than 20 mg/kg; this sample contained arsenic at a concentration of 27 mg/kg.

3.1.2.2 Lead in Soil

Lead (Figure 3-6) is elevated above the site-specific background concentration of 24 mg/kg (as calculated in Appendix D) within some areas of the railyard that coincide with historical railyard operations. On the railyard, elevated lead concentrations coincide with historical operations. The potential sources of lead include sandblast grit, leaded-fuel train exhaust and paint. The maximum lead concentration (3,600 mg/kg) was detected in a surface sample (B-9) from the railyard. Within the railyard, lead concentrations are elevated in the surface soil only. Elevated lead concentrations are present in sporadic surface soil samples from outside the railyard; the sources of this lead are unknown. See Section 4.2.1 for additional details.

3.1.2.3 Polychlorinated Biphenyls in Soil

Low concentrations of PCBs are present near the former transformer pads on the railyard (Figure 3-7). The PCBs are localized in extent and have not been detected anywhere other than close to the site of the historic transformer pads on the railyard. Further details are provided in the *Supplemental RI Report* (RETEC, 2002a).

3.2 Free Product

This section describes the nature and extent of free product. The movement of free product via groundwater through soil is described in Section 4.2.3.

3.2.1 Location and Extent of Free Product

Several discrete areas of free product are present within the site. A site-wide fluid gauging event was conducted in January and February 2002 for the *Supplemental RI*. Figure 3-1 shows the estimated extent of free product throughout the site based on the 2002 measurements. The areas of free product are discontinuous and are present both on and off the railyard. The "apparent" thickness of the free product within the plumes has been as great as 4 feet (in well MW-36); however, it tends to have an average thickness of approximately 0.5 foot (RETEC, 2002a). Between many of these areas of free product are areas of residual product. The lateral extent and location of free product probably changes as a result of water table fluctuations in the smear zone, expanding and contracting within a relatively constant overall area of residual product. This fluctuation also affects the product thickness measured in wells as LNAPL moves slowly with respect to water table changes.

Figure 3-1 also shows areas of suspected free product. No data are available to confirm or refute the presence of free product in these areas; however they have not been included in the areas of known free product based on area soil quality data, groundwater quality data and migration characteristics of the free product.

The largest two free product plumes are present in the northwest part of the site, underlying residential and commercial properties. These two plumes have migrated downgradient from the source areas on the railyard since the original releases, and extend to the northwest and towards the Skykomish River. The migration of free product in the plumes has been curtailed by the installation of the hanging barrier wall in 2001 along West River Road. The rate of migration is slow, as in evidence that the plume is still present within the site, many years after the original releases. The actual rate of migration is not known. Oil was observed seeping into the Skykomish River as early as the 1950s. The data collected by BNSF indicate that some of the product has migrated downgradient from several wells on the railyard since 1993. Further details are provided in Section 8.1.1 of the Supplemental RI (RETEC, 2002a).

Downgradient from the barrier wall, the extent of free product in the levee has not been determined from examination of soils in the levee or soil sample data. However, the locations of seeps in the river bank approximately line up with the plume locations south of the barrier wall; therefore, it is assumed that the plumes extend to the river.

The extent of free product, presented on Figure 3-1, is slightly different from the extent of free product presented in the Supplemental RI. This is based on a more extensive comparison between the fluid-level measurements and the soil and groundwater data, and because fluid levels have been measured from some additional wells (most notably 5-W-5) since the Supplemental RI was completed.

The extent of free product throughout the site appears to have changed with time (RETEC, 2002a). Within the last ten years, free product has been measured in several wells, in the railyard, which no longer contain free product. This suggests that free product has migrated downgradient from an area within the railyard that recently contained free product. The downgradient boundary is largely unchanged; therefore the plume boundaries appear to be shrinking with time (RETEC, 2002a). Conversely, free product has made an appearance in wells (e.g., R-8) close to the barrier wall that previously did not contain free product. However, these wells are relatively close to wells containing product and the overall plume expansion caused by the barrier wall is localized and relatively small.

It should be noted that the rate of migration is relatively slow, and that plume boundaries can fluctuate over time due to changes in the water table, therefore only general assumptions can be made from the product thickness data. The occurrence and thickness of free product has been measured from selected wells on a monthly basis. Table 3-1 presents fluid gauging results from selected wells for 2002 and 2003. These measurements indicate that the thickness of free product in a well may fluctuate over time. Figure 3-8 presents a graph of product thicknesses in MW-36. This shows that the product thickness can vary significantly without showing discernable trends on a monthly basis. Figure 3-8 also presents a hydrograph for the same time period. Comparison of the hydrograph with the product thickness indicates that there does not appear to be a strong correlation between product thickness and fluid levels. With respect to product migration, the rate of change can be measured in years; therefore, the extent of free product can be considered relatively constant for purposes of estimating cleanup requirements.

3.2.2 Physical Properties of Free Product

The predominant types of product used or stored at the railyard were historically bunker C and diesel. Fortnite oil (a kerosene-like product) was reportedly used as a cleaning solution during repair activities that occurred at the maintenance yard from the 1890s to the mid-1940s. In addition, gasoline, and waste oil have been used and stored on the railyard. Free product samples collected at the site are characterized as a mix of diesel and bunker C fuel, consistent with the predominant product types used on the site.

Bunker C is usually blended with lower-molecular-weight fractions, such as diesel, to decrease viscosity and improve flow characteristics. The groundwater contains 43 to 49 percent petroleum hydrocarbons in the diesel range, with the exception of MW-39, which contains approximately 21 percent petroleum hydrocarbons in the diesel range. The free product in well MW-39 consists primarily of bunker C fuel with little, if any, diesel.

Product characteristics have been determined by laboratory analysis of four product samples collected at the site (RETEC, 1996 – Table 6-11). These samples comprise a mixture of diesel and bunker C. The nature of the hydrocarbons in the samples was evaluated using Washington Method WTPH-HCID. Samples were obtained from the river seep near SED-4/SED-5 and from wells MW-22, MW-27 and MW-39, and analyzed for physical parameters including specific gravity, viscosity, surface tension and interfacial tension. The test results are summarized below:

- Specific gravity ranges between 0.9676 (MW-27) and 0.9922 (MW-39). This indicates that the specific gravity is relatively consistent, and that the specific gravity is slightly less than water (Specific Gravity = 1). Therefore, the product will float on water.

- Viscosity at 7.5 ºC (45 ºF) ranges between 1,035 centipoise (cP) (MW-27) to 95,350 cP (MW-39). This indicates that the viscosity varies greatly. This is probably due to the different product composition of the samples. The viscosity of lighter hydrocarbons present in diesel is much lower than the heavier hydrocarbons that are present in bunker C, and the chemical analyses demonstrate that sample MW-39 contains mainly heavier hydrocarbons. The lower viscosities are more typical of the free product present throughout most of the plume area and seeping into the river.

- Surface tension ranges from 33 dynes/cm (MW-22) to 39 dynes/cm (the river seep). Surface tension describes the force required to break the surface of the liquid. The surface tensions of the product samples are relatively consistent and lower than water (72.8 dynes/cm at 20ºC).

- Interfacial tension ranges from 25 dynes/cm (MW-39) to 81 dynes/cm (MW-27). The other two samples contained interfacial tensions of 27 and 49 dynes/cm; this indicates that the value of 81 dynes/cm may be an overestimation since this number exceeds the surface tension of water and is disproportionately higher than the other sample results. Interfacial tension is the force required to rupture the interface between two liquids (in this case, the product sample and water. This varies considerably for the different samples; it indicates that the two liquids will remain fully separate rather than mixing.

3.3 Groundwater Quality

Water has been sampled from shallow screened wells throughout the site to assess the impacts of site contamination on groundwater quality. The most groundwater sampling has been conducted for the Supplemental RI (RETEC, 2002a); this consists of site-wide sampling during January 2002 and January 2003. These groundwater-sampling rounds included samples from approximately 50 monitoring wells, many of which were installed for the Supplemental RI, which have provided the most comprehensive data on groundwater quality for the site. Groundwater samples were submitted for analysis of TPH-Dx. Selected samples were also submitted for analysis of PAHs, BTEX, and/or EPH/VPH. In addition, one sample was submitted for PCB analysis.

3.3.1 Petroleum Hydrocarbons in Groundwater

Groundwater has been contaminated with petroleum hydrocarbons. All groundwater samples have been analyzed for TPH. Groundwater samples have also been collected from selected wells for PAHs, BTEX, and/or EPH/VPH.

3.3.1.1 Total Petroleum Hydrocarbons in Groundwater

TPH in groundwater was analyzed using method NWTPH-Dx. This method reports diesel range (TPH-D) and motor oil range (TPH-MO) organics. TPH-MO is generally not detected in groundwater from the site; therefore, TPH-D represents the extent of TPH contamination in groundwater. Groundwater samples were collected site-wide during January 2002 and January 2003. The January 2002 TPH data are presented in the Supplemental RI (RETEC, 2002a). Figure 3-9 shows the extent of TPH-diesel in groundwater that was measured during January 2003. Table 3-2 presents the TPH data for both sampling events. The TPH-D concentrations from the two sampling events ranged from below detection limit (0.25 mg/L) to 2.6 mg/L in 2002 and 3.33 mg/L in 2003. The highest concentration was present in 2A-W-6 during both sampling events. The highest concentration appears to be in the eastern part of the site. This relates to the eastern free-product plume that contains a higher diesel-to-motor oil ratio.

The TPH-D concentration generally was greatest in or close to the free product plumes in nearby areas that contain high concentrations of residual product. TPH concentrations in the area generally exceed 0.5 mg/L.

3.3.1.2 Polynuclear Aromatic Hydrocarbons in Groundwater

Groundwater samples from selected wells were analyzed for PAHs in January 2002 and in August 2002. The groundwater data (Table 3-3) indicate that concentrations of most PAHs in most groundwater samples were generally below detection levels during both sampling events. Where PAHs were detected, concentrations generally decreased between the two sampling events. The data showed that PAH occurrences are closely related to areas with free product on the railyard. PAHs are not detected in samples collected within 300 feet of the Skykomish River. PAHs may sorb to soil closer to the source and are not as mobile and will not transport as quickly as other chemicals in the plume. This 'partitioning' is another possible reason for the difference in chemical differences across the site.

Fluorene is the most widely distributed PAH, followed by acenaphthene. The data also show a compositional difference between dissolved PAH in the groundwater in the western part of the site and the groundwater in the eastern part of the site. The dissolved hydrocarbons in the western part of the railyard contain elevated concentrations of fluorene and low concentrations of acenaphthene, whereas the dissolved hydrocarbons in the southern and eastern parts of the railyard contain several additional PAHs. The reason for the variations are not fully understood, however the variations are consistent with changes in the hydrocarbon ranges present within the site and probably result from different sources across the railyard.

3.3.1.3 Benzene, Toluene, Ethylbenzene, and Xylenes in Groundwater

BTEX are not significant contaminants associated with the Former Maintenance and Fueling Facility. Groundwater samples from 31 wells were submitted for analysis of BTEX using EPA Method 8020 during the Supplemental RI. The BTEX components were below the detection limits in all samples except for toluene (1.80 µg/L) in MW-11. This is consistent with the BTEX results presented in the Draft RI Report (RETEC, 1996) Groundwater samples were also collected during August 2002 for BTEX analysis (Table 3-4). A comparison of the data collected during the two sampling events indicates that only two groundwater samples have contained BTEX compounds and no consistent trends are evident from the data.

3.3.1.4 Extractable and Volatile Petroleum Hydrocarbons (EPH/VPH) in Groundwater

Groundwater samples collected from 20 wells have been analyzed for EPH/VPH as part of the Supplemental RI. These analysis indicate that they detected fractions are the C10 to C34 aliphatics and C12 to C34 aromatics. EPH/VPH fractions were only detected in groundwater samples from five wells. Only the groundwater sample from MW-39, a well containing free product, contained detectable EPH/VPH in several fractions. EPH/VPH was detected in 2003 but not in 2002 from this well. The discrepancy indicates that free product may have been entrained in the 2003 sample whereas no free product was entrained in the 2002 sample. Furthermore, most of the EPH/VPH results from this well and the others report hydrocarbon fractions greatly above their respective solubility limits. This implies that, where detected, EPH/VPH in groundwater results from the presence of entrained free product in the groundwater samples.

3.3.1.5 Metals in Groundwater

The extent of elevated metals concentrations in groundwater has been evaluated in previous studies (RETEC, 1996; RETEC, 1997). These previous studies concluded that metals are not significant site groundwater contaminants, and that the metals appear to be at background concentrations.

3.3.1.6 Polychlorinated Biphenyls in Groundwater

PCBs were not detected in any wells during the 1996 RI. Thirteen wells located in the vicinity of previous PCB detections in soil or other areas of potential concern were sampled quarterly for PCBs. In 1993, PCBs were detected in well MW-32 at a concentration of 0.11 µg/L (Aroclor 1254). Groundwater samples from MW-32 were tested for PCBs during two quarters of the RI sampling and during the Supplemental RI; PCBs were not detected.

3.3.1.7 Physical Chemistry of Groundwater

For the Supplemental RI (RETEC, 2002a), groundwater samples from selected wells were analyzed for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, turbidity and temperature. The DO data indicate that dissolved oxygen concentrations from samples from wells within areas of known contamination or hydraulically downgradient from these areas (with the exception of MW-44, located west of the barrier wall) are below the detection limit of the field measurement instrument. Dissolved oxygen concentrations in groundwater samples that are not from areas with petroleum hydrocarbon contamination ranged from 0.2 to 5.4 mg/L, which is within the range of typical concentrations of dissolved oxygen in groundwater.

The lowest ORP values are generally present in wells in the vicinity of the railyard. Low ORP values can indicate anaerobic or anoxic conditions often seen in contaminated groundwater. Higher values are present in the wells in the western portion of the site, with the highest value in MW-44.

The pH, turbidity, conductivity, and temperature of groundwater were measured in the field during the Supplemental RI. A summary of the results is provided below.

- pH was 5.02 to 6.47 standard units
- Turbidity was 1.7 and 20.5 Nephelometric Turbidity Units
- Conductivity was 37 to 268 micromhos per centimeter (μmhos/cm)
- Temperature ranged from 2.8 to 8.6 ºC

Additional details are provided in the Supplemental RI (RETEC, 2002a).

3.4 Sediment Quality

There are two separate areas of sediment within the site, as described in Section 2.2.1. These are along the south bank of the Skykomish River and along the former Maloney Creek channel. The sediment quality in these two areas is summarized below.

3.4.1 Skykomish River Sediment

Sediment has been impacted by free product seeps and dissolved groundwater fractions entering along Skykomish River. This has resulted in high TPH concentrations (maximum TPH of 87,000 mg/kg) at the identified seep locations. The TPH concentrations decrease rapidly away from the actual seep locations and data indicates that impacts extend no more than ten feet into the river, and often considerably less.

Sediment along the bank of the Skykomish River has been sampled for the RI and the Supplemental RI (RETEC, 1996; RETEC 2002a). In addition, sediment samples were collected during 2002 for additional sediment bioassays; these samples were analyzed for TPH, EPH/VPH, BTEX, and PAHs. Figure 3-10 shows the extent of TPH in the sediment along the bank of the Skykomish River. The results from this testing and a more complete discussion of the sediment sampling are presented in Appendix B.

3.4.2 Former Maloney Creek Sediment

As part of the Supplemental RI additional investigations were conducted in the former Maloney Creek channel and in adjacent areas. Figure 3-11 presents a longitudinal transect from sample 3-SD-1 downstream of the culvert to 2B-SD-6 immediately downstream of the upper road culvert and five transverse transects. The profiles show that the fine-grained sediment is limited in vertical extent, and that although TPH is present within the shallow sediment, higher concentrations are present in the underlying sand and gravel. The contamination data is summarized on Figure 3-11 in two ways: (a) impacted (visual, odor, sheens, or product) soil noted during the drilling is indicated by cross-hatching, and (b) TPH-T (diesel and lube oil range) values from collected samples in the intervals indicated next to the boring.

The transects indicate that the following distinct segments can be identified in the former Maloney Creek channel, based on differences in topography and lithology. These areas are described in Section 2.2.2 and are summarized below.

1) An upstream segment with a steep gradient in which the channel is narrower and channelized between steeper banks, and essentially is a drainage ditch for the Old Cascade Highway and surrounding residential areas. This section contains silty sand (possibly older fill material) in the surface layers. The sample 2B-SD-6 is located at the point were the drainage ditch widens into a marshy swale.

2) A middle segment encompassing samples 2B-SD-5, 2B-SD-4 and 2B-SD-3. This area has a gentle gradient and wider profile and one to three feet of silty sediment typically overlays the alluvial sands and gravels typical of the area. This area is wooded and marshy, with slower water flow and presence of side channels and marshy swales. The section narrows just south of 2B-SD-5 by a private residence and adjacent yard. A pool area is present on the western end of this segment containing samples 2B-SD-2 and 2B-SD-1. At 2B-SD2 gravelly alluvial material reaches the surface and may represent an old riffle area with steeper slope. Downstream of 2B-SD-2 a deeper scour or plunge pool is present behind the road culvert. The plunge pool is filled with a foot of silt overlying 5 feet of silty sand. The pool area is marshy and open, lacking tree growth.

4) A segment downstream of the 5th Avenue/Old Cascade Highway culvert. This portion is a steeper, scoured channel, with limited accumulation of fines. This area has the characteristics of a creek. Sample 3-SD-1 was collected here.

Groundwater gauging data indicate that groundwater levels are located well below the bed of the channel during seasonal low groundwater levels. During measured seasonal highs the groundwater typically rises to within a foot of the channel, and at times groundwater may surface in the former creek bed. This is significant because it indicates that hydrocarbons that are typically contained in the sand and gravel that underlies the former channel may in some areas also affect the shallow sediment contained within the channel (i.e. the sediment is within the groundwater smear zone).

Low concentrations of TPH, up to 48 mg/kg, were detected in sediment from the upper segment.

The middle segment of the former Maloney Creek channel is underlain by contaminated sand and gravel in the smear zone below the surface sediment. This contamination in the smear zone is continuous with the affected property, and is similar in concentration, type, and hydrogeological characteristics to that found in the surrounding soils. In general, contamination is greater in the sand and gravel beneath the surface sediment and does not appear to be significantly impacting the sediment near the ground surface. This is illustrated on Figure 2-5, where it can be noted that visibly impacted subsurface soil is generally confined to the deeper gravel layers, as is the situation in the adjacent railyard. Near-surface concentrations of TPH are notably lower than in the visibly impacted deeper layers. This suggests that there appears to be no upwards transport component of contaminants in most of the former Maloney Creek channel.

However, in the area around 2B-SD-5, substantial contamination is present close to the ground surface, particularly immediately adjacent to the private residence at location 2B-B-4. This is the only area where the subsurface smear zone extends into the silty depositional material. This contamination could be due to smearing of underlying contamination in groundwater or possibly from historic drainage into the channel through an oil drain immediately upstream of 2B-SD-5 (Figure 2-2).

The lower segment (pool area) upstream of the culvert contains moderate contamination (500 mg/kg TPH) in the depositional surface layers. This area functions as a sink for contaminated sediment from upstream, as evidenced by the deep layer of sedimentary material at this location. Deeper sediment shows declining concentrations, indicating that older, historical releases, if any, are not resulting in significant deleterious impacts. No high concentrations of TPH indicative of residual contamination remaining from the time when active discharge occurred to the channel are present.

The channel section downstream of the culvert contains some contamination with TPH immediately downstream of the culvert, however the lower section is generally scoured free of fine-grained sediment, and therefore contamination is unlikely to accumulate in this area for extended periods of time.

The hydrocarbon composition provided by EPH/VPH data (RETEC, 2002a) indicates that the TPH is similar to that found elsewhere throughout the site, with heavier aliphatics and aromatics typical of diesel and motor oil range hydrocarbons (TPH-MO) predominant. PAHs were detected in the smear zone of the former channel, where TPH concentrations are highest; however, PAHs are generally absent from the surface sediment and underlying sediment (0 to 2.5 feet). Note that although surface sediment is defined as the top 10 centimeters, sample collection consisted of a composite of the top 2.5 feet, and is here used as an estimate for the surface sediment. BTEX is absent from the sediment, which is consistent with the soil and groundwater quality in this area. Metals (arsenic and lead) were consistent with background concentrations. PCBs were not detected within the sediment at quantitation levels generally in the 0.1 mg/kg range or less (RETEC, 2002a).

3.5 Surface Water Quality

Site groundwater recharges the two surface water bodies in the study area: the South Fork of the Skykomish River and occasionally the former Maloney Creek channel. Free product seeps migrate slowly into the river throughout much of the year, and groundwater with dissolved petroleum hydrocarbons flows into the river. The river level seasonally varies with flow. There are generally two high and low flow periods each year. One of the periods of high flow generally occurs in November through early March, the other high flow period occurs between May and July during runoff from snowmelt.

Seeps have not been observed during high flow conditions. This is probably largely because the seepage face is submerged under several feet of fast flowing river water. The seeps are also likely to be less during times of high water because the hydrostatic pressure from the higher river water would form resistance to seepage, and the water would also lower the temperature of the product and increase the viscosity, resulting in more limited product mobility.

During low water conditions, the riverbank is typically dry and there are either pools of water close to the bank or low flowing water. The seeps are more noticeable during these times and product seeps may lead to sheens on the water close to the bank, or accumulate in pools of low/no flowing water. Booms have been placed and maintained along the riverbank as an interim cleanup action, to contain the product close to the actual seep locations. Absorbent pads are used to clean up seeped petroleum. Surface water samples were collected from seven locations in the Skykomish River, Maloney Creek and the former Maloney Creek channel on four occasions during the RI (RETEC, 1996). Surface water samples show that there are generally no impacts to surface water in the Skykomish River, Maloney Creek, or the former Maloney Creek channel. (Table 11-15, RI Report)

Surface water temperature, pH, DO and conductivity were collected as part of the RI sampling (RETEC, 1996). These data indicate that the water in both the South Fork of the Skykomish River and the former Maloney Creek channel is neutral to basic (6.6 to more than 10 standard units [su]), has relatively low conductivity (22 to 338 µmhos/cm), and is well oxygenated (greater than 9 mg/L DO). No significant differences were noted between the river readings and those from the creek.

3.6 Air Quality

Air monitoring was conducted during drilling and excavations for the RI (RETEC, 1996: RETEC 2002a). This monitoring indicated that vapors from petroleum hydrocarbons have not adversely impacted air quality. This data demonstrates that there is no significant potential for migration of volatile compounds to the air from impacted soil and groundwater. During health and safety monitoring for the Supplemental RI, readings of total volatile organics taken during sampling were consistently non-detect in the breathing zone, with the exception of one reading of 0.5 parts per million (ppm) during sediment sampling. Volatile organics were only detected at appreciable levels during hollow-stem auger drilling of boring B-10, and from the top of the casing during air rotary drilling of boring B-7.

In most cases, detected values correspond to wells with measurable free product accumulations. Only four compounds have estimated air concentrations that total greater than 0.00001 mg/kg, including mercury, 2-methylnaphthalene, butyl benzyl phthalate, and xylenes.

Indoor air sampling was performed under the 1993 Agreed Order with Ecology in six buildings between 1997 and 1999. Samples were analyzed for an extensive suite of VOCs by EPA Method IP-1A and SVOCs by EPA Method IP-7. Indoor air was sampled in response to requests by Skykomish residents. The Washington State Department of Health (WDOH) in its "Health Consultation" dated August 30, 1999 concluded that 'exposure to contaminants detected in indoor air over the seven sampling events are not at concentrations expected to pose a health threat' and that 'there were no apparent public health hazard from exposure to contaminants detected in any of the locations' and communicated this conclusion to the public by issuing an "Environmental Health Update" in June 1999 (WDOH, 1999) and presenting their findings at a public meeting in Skykomish.

3.7 Summary of the Nature and Extent of Contamination

The following summarize the conclusions of the nature and extent of contamination:

- The most common contaminant at the site is petroleum hydrocarbons. These have been measured as TPH, PAH, BTEX and EPH/VPH.

- It is estimated that several plumes of free petroleum product are present at the site. These plumes are present on the railyard, in residential and commercial areas, and along the riverbank as free product seeps through portions of the riverbank west of the Skykomish River Bridge.

- The highest concentrations of petroleum hydrocarbons in soil, groundwater and sediment are typically present in the same location as free product.

- Petroleum hydrocarbons are present in the surface and vadose zone in historical source areas on the railyard and limited areas off the railyard. These areas may contain high TPH concentrations in the surface zone and vadose zone soil, but do not always coincide with the highest concentrations of TPH in smear zone soil.

- TPH is more widespread in the smear zone, and is typically found in both the soil and groundwater. This distribution is due to migration of petroleum hydrocarbons as free product with groundwater downgradient from the original source areas.

- Free product has migrated to the Skykomish River and is seeping through the banks into the river. The impacts to sediment in the Skykomish River appear to be restricted primarily to those seep locations.

- Shallow sediment in the former Maloney Creek channel, adjacent to the railyard, has been impacted. The shallow sediment in the creek is underlain by sand and gravel with high TPH concentrations similar to the condition observed in surrounding smear zone soils. The sediment contamination may result from smearing from the underlying soil at times of high groundwater levels.

- Elevated concentrations of lead and arsenic are present in some soil on the railyard. These concentrations are restricted to the surface zone soil.
- Lead and arsenic are not elevated in groundwater.
- There are some isolated areas with lead in surface soil in the residential/commercial area north of the railyard. The source(s) of this lead are unknown.
- PCBs have been detected in surface soil from portions of the railyard. The PCBs are generally present in the vicinity of the former substation and old transformer pads.
- PCBs have not been detected in smear zone soil or in groundwater anywhere throughout the site.

3.8 Indicator Hazardous Substances

This section selects indicator hazardous substances for purposes of defining site cleanup requirements. Indicator hazardous substances are the compounds found at the site that are most prevalent and comprise the greatest risk to human health and the environment at the site. Also, by focusing site cleanup on these compounds, the majority of the risk at the site is eliminated.

MTCA allows for the elimination "from consideration those hazardous substances that contribute a small percentage of the overall threat to human health and the environment. The remaining hazardous substances, or indicator hazardous substances (IHSs) can be implemented at sites that are contaminated with a large number of hazardous substances" for monitoring during "any phase of remedial action for the purpose of characterizing the site or establishing cleanup requirements for the site" (WAC 173-340-703). The use of IHSs in development of a final remedy for this site is appropriate, because from the large number of chemicals, only a few have been detected commonly and only a few contribute to a significant overall threat. The RI (RETEC, 1996; RETEC, 2002a) was designed to investigate the presence and distribution of all hazardous substances at the site.

The data collected for the RI has been subjected to a rigorous screening process to develop the list of IHSs for the Skykomish site. Note that TPH is considered an IHS for all media, and was not subjected to the screening process. Details of the analysis are presented in Appendix D. This information is summarized below by medium and in Table 3-5:

- In addition to TPH, soil at the site has eight IHSs: arsenic, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene and indeno(1,2,3-cd)pyrene.

- In addition to TPH, the sediment has the following four IHSs: lead, benzo(a)anthracene, benzo(b)fluoranthene and chrysene.

- The groundwater IHSs consist of TPH, benzo(a)anthracene, chrysene and fluoranthene.

- Surface water does not contain any IHSs as such, other than TPH; however, since groundwater discharges to surface water and groundwater must be protective of surface water, the IHSs for groundwater will also apply to surface water for purposes of developing cleanup levels in Section 5.

The distribution and movement of IHSs is summarized in Section 4, as part of the Conceptual Site Model.